Space Weather Technical Forecast

Issued on Saturday 1 February 2025 at 12:34 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: G1 Minor Storms likely Days 1-2 (01-02 Feb) from fast winds and potential CME glance. Further M-class flares expected.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate solar activity over the last 24 hours, with two M-class flares, reaching a peak of M6.7 at 31/1406 UTC. There are eight active regions on the Earth-facing disc. The majority of the activity is from a cluster of sunspots in the northeast, consisting of AR3976, AR3977 and AR3978. These form a complex area of multiple small spots, with ongoing slow development. The recent flare activity appears to originate from between AR3976 and AR3978, where there is a clear filament structure in SDO aia-304, potentially sigmoidal in shape. This suggests the ongoing potential for notable flares from these regions. There are a number of small and simpler regions across the rest of the disc, however any growth of these remains limited.

A CME was observed leaving the Sun due to the M6.7 flare from the northeast disc. This has been assessed as missing Earth behind and to the north.

Solar Wind / Geomagnetic Activity: Solar winds as measured by ACE at L1, showed the onset of a connection to CH11/+. Wind speeds were initially background around 350 km/s, rising slowly to strong levels around 600km/s. Density was above average early in the period, but is now below average. Interplanetary Magnetic Field, Bt, has been moderate to strong, peaking at 18nT. The north-south component, Bz, has been strongly variable, between +16/-17nT. Phi angle was initially negative (towards the Sun), but switched positive just after 31/2200 UTC. Geomagnetic activity was initially Quiet (Kp 2), becoming Unsettled to Active (Kp 3-4) later in the period.

Energetic Particles / Solar Radiation: High energy proton flux at GOES18 was at background levels. High energy electron flux (greater than 2MeV) at GOES16 was at background levels. The associated 24-hour fluence persisted below the Active threshold, recording 9.1e5 integrated pfu at 01/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is expected, with a slight chance of X-class flares, primarily from the regions on the northeast disc.

Solar Wind / Geomagnetic Activity: There is one CME in the forecast, which left the Sun around 30/1400 UTC and could give a glance on Day 2 (02 Feb). There is uncertainty in the possible

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geomagnetic response to this - it is most likely to be a glancing blow with little significant effect, but with potential for something stronger. Earth is currently connecting to the fast wind from CH11/+, and speeds may become strong around 600 km/s. Peak winds are likely to occur around the arrival of any CME glance, before wind speeds gradually ease during Days 3 and 4 (03-04 Feb).

Unsettled to Active geomagnetic activity is expected, with a likelihood of G1/Minor storms on Day 1 (01 Feb), and a slight chance of G2/Moderate Storms. This continues on Day 2 due to both the potential CME and the ongoing fast winds, but with a slight chance of G3/Strong storms should the CME be more geoeffective. Activity then easing during Days 3-4, to be Quiet to Unsettled with isolated Active intervals.

Energetic Particles / Solar Radiation: GOES18 high energy proton flux is likely to be at background levels, but with a slightly increasing potential of responding to any notable flares as the sunspot regions in the northeast move towards the western hemisphere. GOES16 high energy electron flux is likely to show a rising trend later in the period, possibly reaching Moderate to High levels from Day 3 (03 Feb). The 24-hour fluence is likely to remain below the Active threshold, but with an increasing trend from Day 3 (03 Feb).

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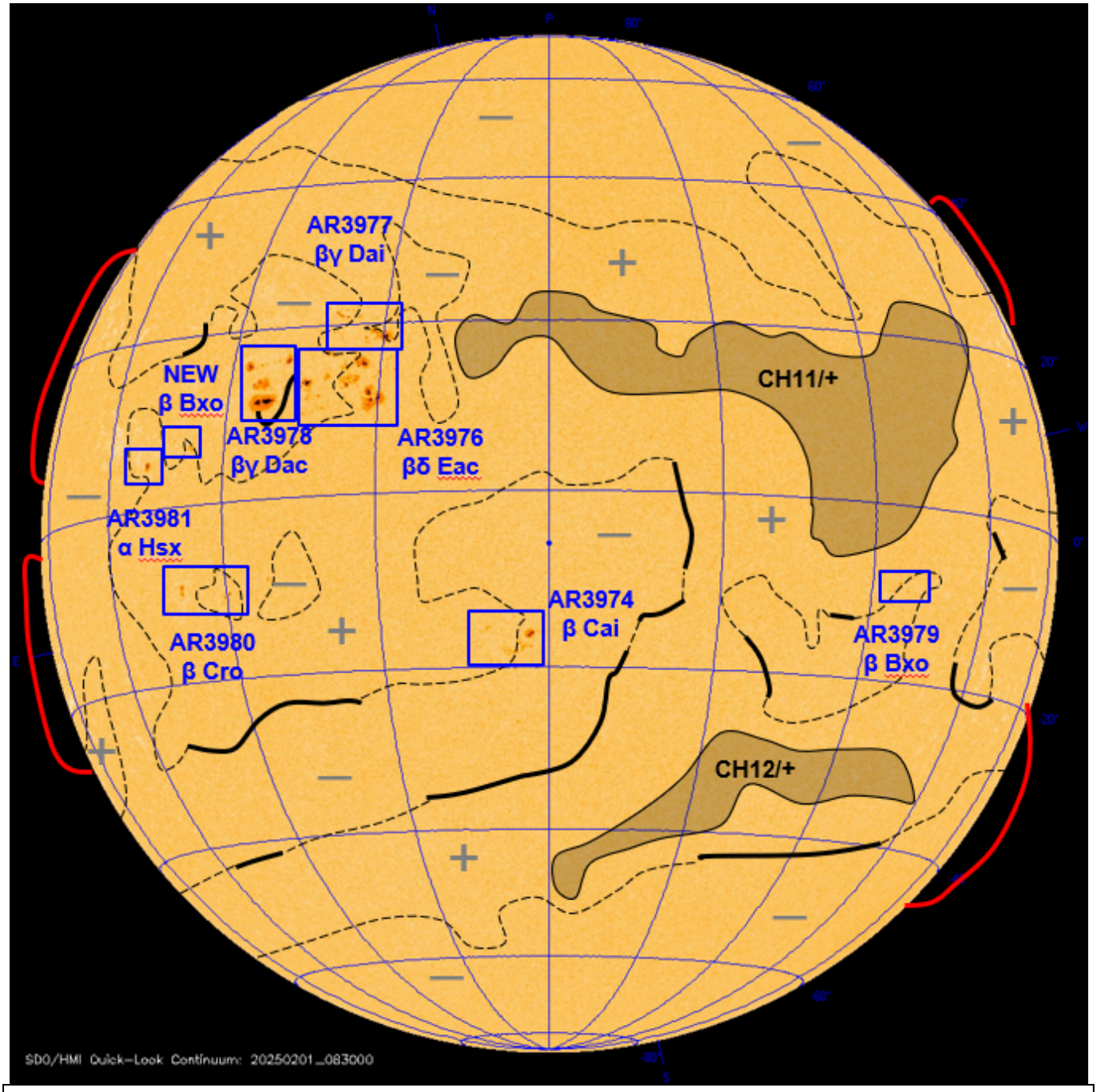
Figure 1: Solar synoptic map, valid 01/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

There is one CME that could affect this forecast, however confidence is low. This was from a multi-stage filament eruption off the southeast disc around 30/1400 UTC. This has been modelled as passing mostly behind and south of Earth, however an arrival is possible on Day 2 (02 Feb). There is significant uncertainty in the potential geoeffectiveness of this feature - any arrival would probably be just a glancing blow with little significant effect. However, if we do see some of the main bulk of the CME, it could give a more significant geomagnetic response due to the potential high density from its filament origin. There was a second CME from the M6.7 flare of AR3976/AR3977 at 31/1406 UTC, but analysis suggests this will miss Earth.

Earth is now connected to the fast wind from CH11/+, a little later than originally expected, with wind speeds now strong at 600 km/s. It is possible that speeds may continue to increase over the next day or so, perhaps reaching 700 km/s, but confidence here is low. While positive polarity coronal holes are unfavourable for strong connections at this time of year, the strength of the wind and the persistence of the feature which brought G1/Minor storms on the last rotation, suggest that this could still be a geoeffective feature. Furthermore, peak wind speeds are likely to continue until any arrival from the CME mentioned above, before wind speeds gradually ease during Days 3 and 4 (03-04 Feb). This is in agreement with current MOSWOC Enlil, which is providing reasonable guidance at present.

Unsettled to Active geomagnetic activity is expected, with a likelihood of G1/Minor storms on Day 1 (01 Feb), and a slight chance of G2/Moderate Storms. This continues on Day 2 due to both the potential CME and the ongoing fast winds, but with a slight chance of G3/Strong storms should the CME be more geoeffective. Activity then easing during Days 3-4, to be Quiet to Unsettled with isolated Active intervals.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	**G1 to G2**	No	60	50	20	5
Strong	**G3**	No	1	10	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

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Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
30/2345	Partial	Filament	29E 27S	570	02/1200 +/ 10hrs	Low confidence, probable glancing impact.

Figure 2: MOSWOC Enlil showing a reasonable trend with the wind speeds over the next few days.

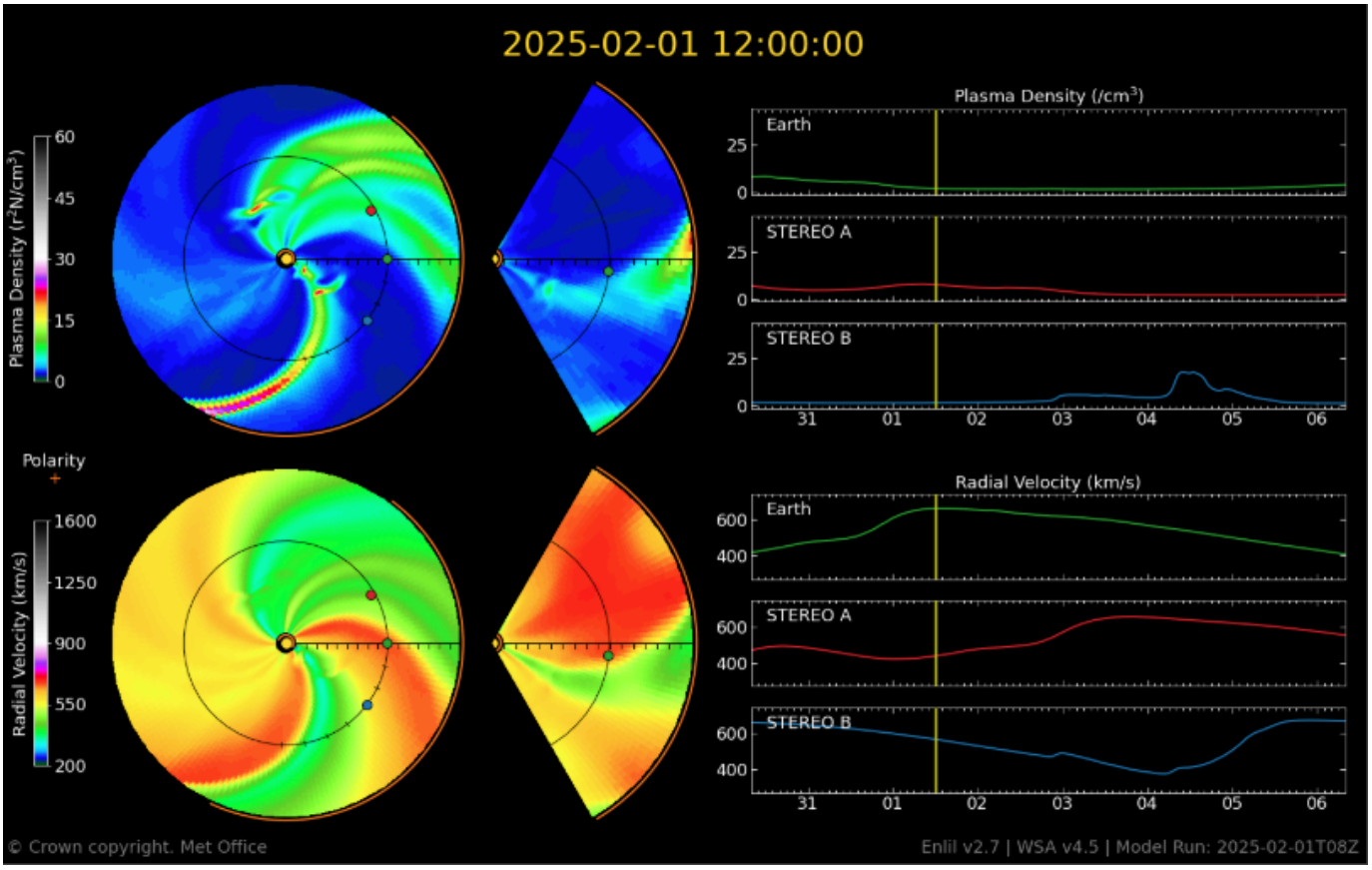

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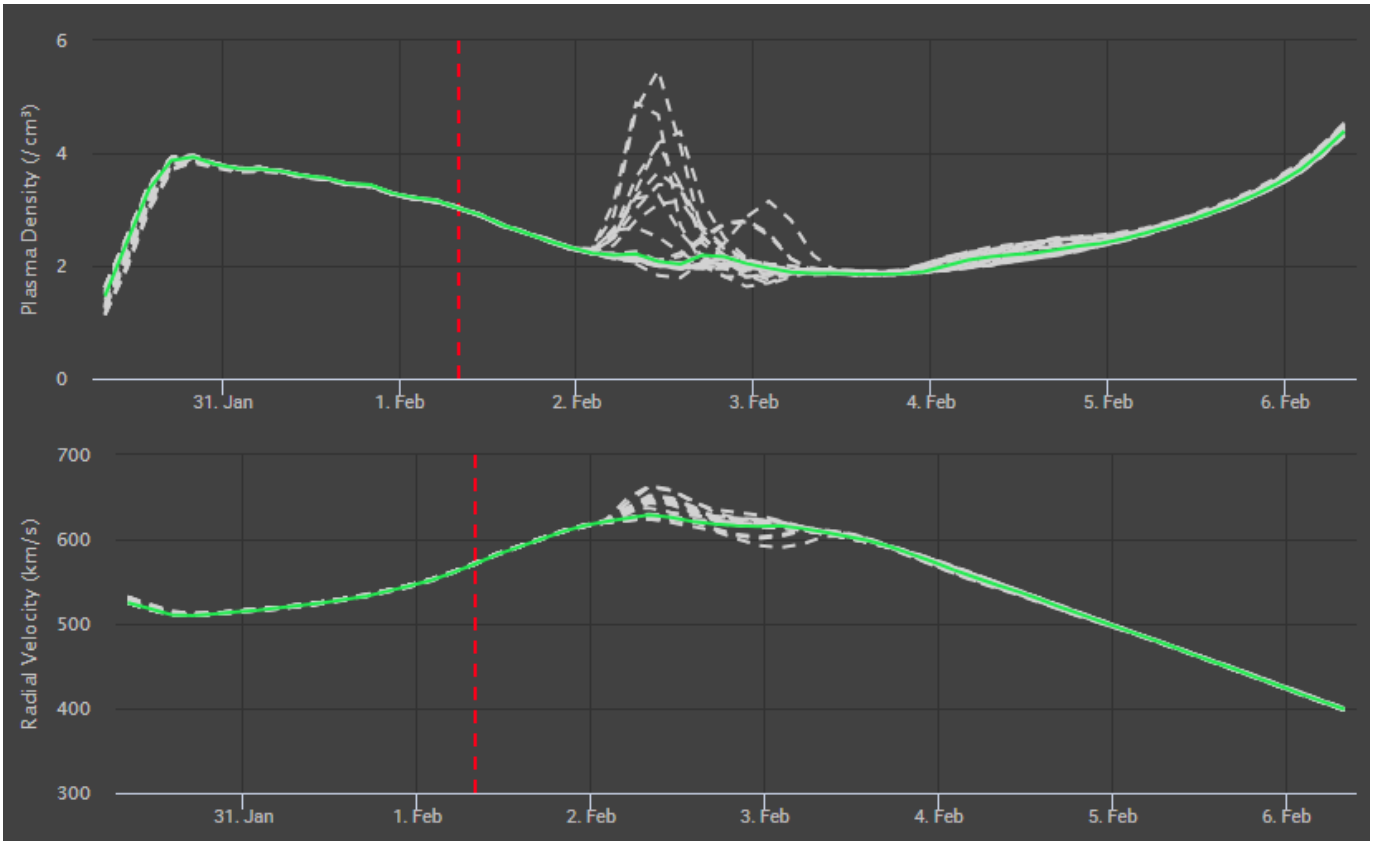
Figure 3: Enlil ensemble, showing the potential for a CME arrival on 02 Feb.



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Radio Blackouts - X-Ray Flares

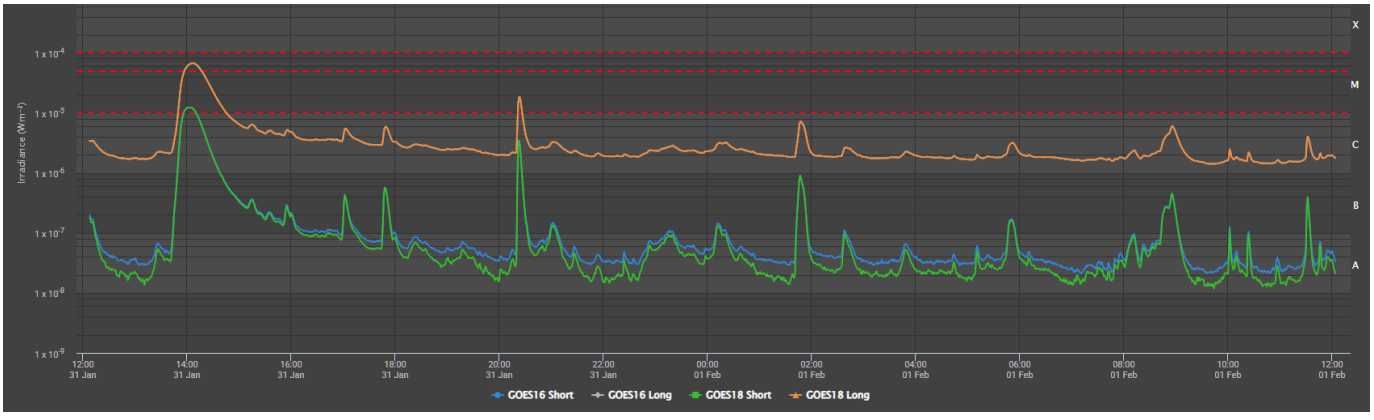
Moderate solar activity over the last 24 hours, with two M-class flares, reaching a peak M6.7 at 31/1406 UTC from the connection between AR3976/AR3977.

There are currently eight active regions on the Earth-facing disc. The majority of the activity is from the cluster of sunspots in the northeast, consisting of AR3976, AR3977 and AR3978. These form a complex area of multiple small spots, with ongoing slow development, and signs of magnetic interaction between the different regions. Whilst AR3976 seems to have lost its weak delta spot, AR3978 has started to develop one in its intermediate spot. The recent flare activity appeared to originate from between AR3976 and AR3978, where there is a clear filament structure in SDO aia-304 imagery, potentially sigmoidal in shape. This suggests the ongoing potential for notable flares from these regions. There are a number of small and simpler regions across the rest of the disc, however any growth of these remains limited.

None of the larger regions are due to rotate off the disc in the coming days, and currently no significant regions are expected to rotate onto the disc. Further M-class flares are expected throughout, with a slight chance of an isolated X-class flare.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	75	75	75	75
Very Active	R3-R5 (X Class)	No	15	15	15	15

Figure 4: X-ray flux at GOES16 and 18 over the last 24 hours.



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Solar Radiation Storms (High Energy Protons)

Proton flux as observed by GOES-18 is currently at background levels, and is likely to remain that way through this forecast period with the majority of the current solar activity on the northeast disc. As these regions move into the centre-disc, and then into the western hemisphere, there is a slightly increased chance of proton flux rising in response to any notable flares.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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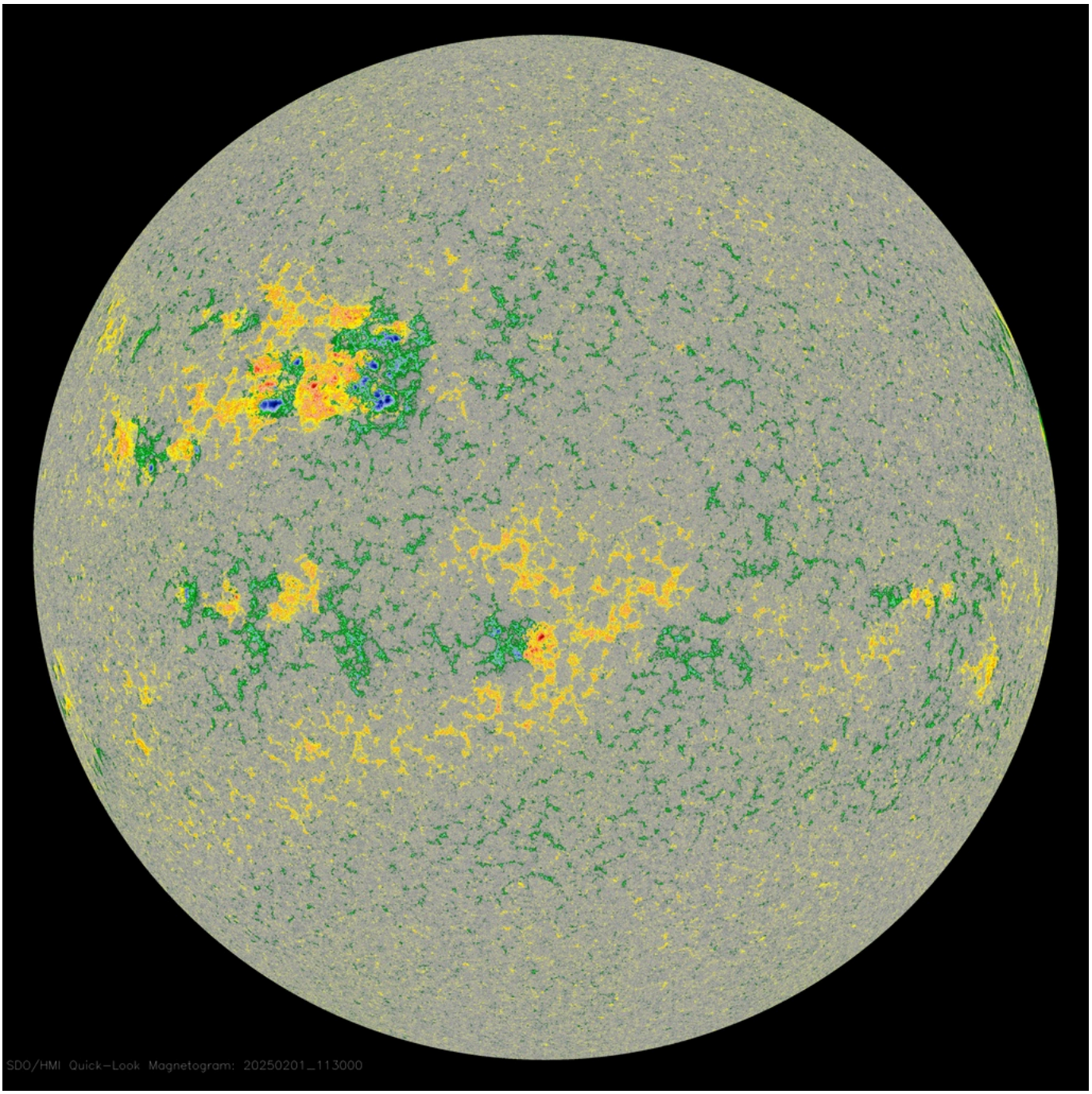
Figure 5: SDO magnetogram, showing the complex of sunspots in the northeast disc which could have potential to give proton flux increases, particularly when they reach the western hemisphere.



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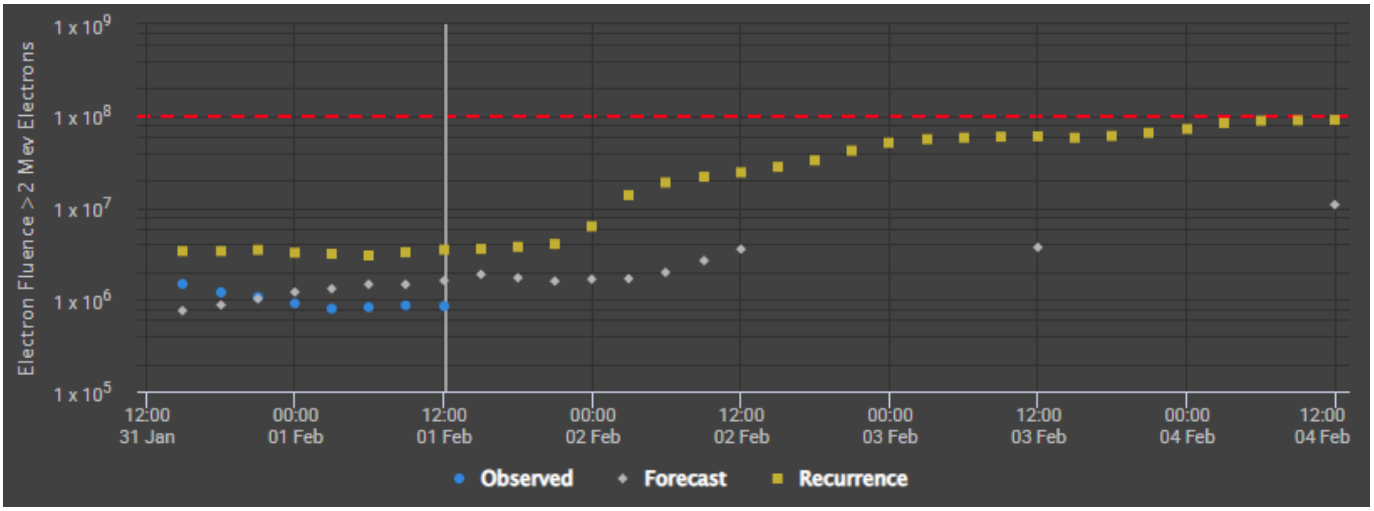
High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 is currently at background levels. However, the onset of fast winds from CH11/+, potentially alongside any enhanced geomagnetic activity from the potential CME glance on Day 2 (02 Feb), is likely to charge the Van Allen belts at lower orbits. As the wind speed eases on Days 3-4 (03-04 Feb), the Van Allen belts should expand back towards GEO, potentially bringing an increase in flux at this orbit. Flux could rise to Moderate later in the period, with a chance of reaching High at the diurnal peak.

The corresponding 24 hour fluence is expected to persist below the Active threshold Days 1-3, but with a possible rising trend Days 3-4, bringing a slight chance of reaching the Active level by the end of the period. Any rise above Active is more likely to occur after the end of this forecast period, in the absence of further CME activity. REFM is currently providing good guidance for Days 1-2, but currently does not properly capture the likely rising trend from Day 3.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^8	No	1	1	5	20
Very Active	≥ 2 MeV ≥ 1×10^9	No	1	1	1	1

Figure 6: MOSWOC REFM, forecasting a slight rise (in white) by Day 3 which may be slightly underestimated. By contrast the recurrence value (in yellow) is likely to be overestimated as the high speed stream arrived earlier on the previous rotation. It is an indication of the potential after the end of this forecast period, however.



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